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U. S. Department of Transportation
before the
Senate Committee on Commerce, Science, and Transportation
Subcommittee on Surface Transportation
and Merchant Marine

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Madam Chairman and members of the Subcommittee, thank you for this opportunity to appear before you again. At the Subcommittee's February 25 hearing, I reported to you on major improvements in railroad safety, the partnerships we have fostered through the Safety Assurance and Compliance Program to achieve those improvements, our current initiatives under that program, recent developments in crossing safety programs, and the status of our principal rulemakings. A summary of major rules issued since that hearing and an update on three pending dockets are found at Appendix A to my testimony.

In my prior testimony, I emphasized that at no time in history has so much concentrated change affected rail transportation in our country. Spurred by increases in international trade, rail intermodal traffic has increased 40 percent since 1990—up 7 percent in 1997 alone. This means more and faster trains competing for space on increasingly congested railroads. In some ways the railroad industry is becoming an industry of extremes, as recent mergers have produced mega-railroads while at the same time shortline and regional railroads have proliferated. This

enormous restructuring, focused on competitive gains, clearly has raised issues of safe operation. Simultaneously, as rail traffic has expanded significantly, increasing more than 30 percent in revenue-ton-miles since 1990, railroad employment has fallen to the lowest number in this century, about half the number in 1980. Not surprisingly, operations on these huge systems have dramatically increased fatigue in employees and supervisors, increased the complexity of communications, and created other human factor safety hazards.

In fact, accidents/incidents caused by human factors account for about one-third of the rail equipment accidents/incidents as well as many personal injuries. These hazards include not only fatigue and the broad, overlapping category of safety culture, but also inadequate training, ambiguous or conflicting railroad operating rules, impairing substances, technology that is not designed to work in the same manner that human beings typically think and work, and other causes. Human factors caused 31.5 percent of reported rail equipment accidents/incidents in 1991, 34.1 percent in 1992, 31.1 percent in 1993, 34.1 percent in 1994, 36.0 percent in 1995, 30.3 percent in 1996, and 33.4 percent in 1997. (A statistical chart at Appendix B provides the raw numbers on which these percentages are based.)

To address this critical safety threat, FRA has employed a multifaceted approach. In my February 25 testimony, I briefly summarized our partnership efforts to deal with the important issue of fatigue in the railroad industry, both through the Safety Assurance and Compliance Program and the North American Rail Alertness Partnership. Today, I will elaborate further on those voluntary efforts to combat fatigue, describe research studies on fatigue sponsored by FRA,

and talk about provisions of the Administration's safety bill, the Federal Railroad Safety Authorization Act of 1998, that focus squarely on combating fatigue. That bill, which was introduced by request in the House as H.R. 3805 and in the Senate as S. 2063, attacks perhaps the most pervasive safety issue in the railroad industry−fatigue that hampers the alertness, mental acuity, and judgment of operating employees. The bill offers railroad management and labor incentives to come to agreement on ways to reduce on-the-job fatigue and fatigue-caused accidents/incidents through comprehensive fatigue mitigation plans. Voluntary cooperative efforts being piloted on at least three major railroads offer great promise, and our proposal is designed to expand on those efforts. Passage of this bill is an essential element of our shared goal of zero incidents, zero injuries, and zero deaths in the railroad industry. As further detailed in Appendix C to my testimony, there has been a dramatic increase in railroad safety over the past five years: a 17-percent reduction in railroad-related fatalities; a 46-percent drop in on-the-job casualties; an 8-percent decrease in the rail equipment accident/incident rate; and a 21-percent decline in grade crossing collisions. These achievements reflect the success of FRA's entire safety program, but we will never be satisfied until we have no derailments, no collisions, no fatalities, and no injuries to report.

In holding this hearing on fatigue in both the railroad and trucking industries, the Subcommittee recognizes that fatigue is an issue that cuts across all modes of transportation. Let me assure you that the agencies of the Department of Transportation operate as One DOT. As I will be discussing in more detail, FRA works closely with the other DOT modal administrations through the DOT Safety Council and the DOT Human Factors Coordinating Committee.

Although we are governed by different statutes and have different statutory tools with which we can deal with fatigue, we approach the issue from a common understanding and are, in concert, examining ways to address fatigue issues as One DOT.

The Federal Hours of Service Laws

The Federal hours of service laws govern the on-duty and off-duty periods of railroad employees who perform certain functions. These laws were enacted in 1907, over 90 years ago. Congress last adopted major amendments to them in 1969, almost 30 years ago, when it reduced the maximum on-duty period for train service employees from 16 hours to 12 hours. The hours of service laws limit the work hours of railroad employees who are engaged in duties so related to the safe operation of trains that physical and mental fatigue causing diminished job performance endangers themselves, their coworkers, and the public. Covered employees fall into three categories: those involved in train and engine service (e.g., train crews); those involved in giving mandatory orders directing train movements (e.g., operators and dispatchers); and those in signal service (e.g., installers, maintainers, and repairers). As the Supreme Court explained in a 1917 case, the hours of service laws were passed because

> of the many casualties in railroad transportation which resulted from requiring the discharge of arduous duties by tired and exhausted men whose power of service and energy had been so weakened by overwork as to render them inattentive to duty or incapable of discharging the responsibilities of their positions.

Atchison, Topeka & Santa Fe Ry. Co. v. United States, 244 U.S. 336, 342 (1917). In that case, the Supreme Court was describing a category of human factor accidents/incidents marked by lack of alertness or slow response time, not limited to those caused by the extreme fatigue that manifests itself in the unconsciousness of sleep.

Unfortunately, despite the intentions of Congress, the statute provides only rudimentary protections against on-the-job fatigue. In very general terms, train crews are allowed a maximum of 12 hours on duty in a 24-hour period, and must have a minimum of 8 or 10 hours of rest. While the hours of service laws are an important component of FRA's fatigue-mitigation strategy because they establish minimum standards for fatigue-prevention, it is obvious that even full compliance with those parameters does not necessarily control fatigue. For example, the laws technically would permit an employee to work in safety-sensitive service for 365 days a year without ever having a rest period longer than 10 consecutive hours. More important, the hours of service laws do not address what our society has learned scientifically and otherwise about fatigue over the last 30 years. While adjusting the parameters in the hours of service laws could have some beneficial effect on fatigue, we believe it is necessary to look at much more than just maximum work hours and minimum rest time in a 24-hour period. Modern experience has shown that the basic protection of these laws must be supplemented by a broader, more comprehensive approach to fatigue mitigation.

Human Factor Accidents/Incidents

Working together as One DOT through the DOT Safety Council and the DOT Human Factors Coordinating Committee, FRA and the other modal agencies have recognized an opportunity to enhance safety by reducing human factors accidents/incidents. The mission of the DOT Safety Council is to promote a safe U.S. transportation system through coordinated DOT safety programs focusing on key cross-cutting issues and a safety message to the public embodying a commitment to safety first. One of the key cross-cutting issues affecting all transportation modes that the Council has identified is fatigue. Research efforts on fatigue have been shared among the modes as part of the Safety Council's work. In addition, as teams, including the DOT Human Factors Coordinating Committee, have continued to work collaboratively to develop and implement fatigue mitigation measures, best practices of individual modes have been shared.

Human errors contribute significantly to most transportation crashes across all modes of transportation. Reducing these errors by increasing attention to human performance and behavior issues will reduce the personal and financial burdens associated with crashes. Such costs include not only lost days of life and functionality, but also expenses associated with crash clean up, injury treatment, property damage, workplace disruption, insurance claims processing, and legal proceedings, as well as public assistance for the injured.

Awareness of the role of human performance and behavior issues in transportation is increasing at a time when new technologies are being introduced to improve transportation system safety, reliability, and productivity. However, the capabilities of these technologies often are

compromised because the full range of human performance and behavior issues associated with transportation system design, use, operation, and maintenance were not considered. The use of a “human-centered” systems approach to the design, development, and implementation of technologies is necessary to ensure that the full potential of these technologies can be realized. This potential includes achieving the desired gains in safety, reliability, and productivity, as well as public support for, and acceptance of, these technologies.

The "human-centered systems" approach focuses on human capabilities and limitations with respect to human/system interfaces, operations, and systems integration. The goal is to design transportation technology that facilitates task completion, so that people can focus on task performance and not be distracted by the technology. This encompasses development of a generation of machines that are adaptable to their human operators, rather than depending on human beings to adapt to machines. By incorporating human performance and behavior principles into the design of transportation systems, it will be possible to improve safety. Improved safety will be accompanied by increases in capacity, operational efficiency, and productivity.

A coordinated, proactive human factors research program is essential to ensure that the necessary data and methods are available to the U. S. industries responsible for designing and implementing advanced technologies for our transportation systems. This program should be multi-modal and multi-agency, involve the public and private sectors, and ensure synergy among the modal research programs.

The program includes modal-specific elements within DOT, multi-modal programs, and

interagency research efforts. In the near-term, the research efforts will focus on two new multi-modal human performance and behavior initiatives relating to Fatigue Detection and Alertness Enhancement, and to the use of Advanced Instructional Technology. Potential additional future multi-agency projects may include efforts relating to the following issues:

* Operator education, qualifications, and training;
* Human/systems interfaces;
* Cognitive workload;
* Situational awareness;
* Diversity, aging, and mobility requirements;
* Effects of prescription drugs on performance; and
* System-induced error.
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Fatigue in the Railroad Environment

Railroad employees want to work safely and efficiently. They know that their own lives, as well as the lives of others, depend on consistent compliance with operating rules, signal indications, and other safety requirements; but these safety and performance requirements are often compromised by employees' inability to obtain adequate rest in existing railroad operations. Available information suggests that these employees face real challenges in managing their work and rest due to the demands of railroad operations and the rigidity of some existing work rules.

As previously mentioned, about one-third of the rail equipment accidents/incidents and

many personal injuries occur due to human factors. In 1997, for example, 855 of the 2,560 rail equipment accidents/incidents (33.4 percent) were caused by human factors. While only two of these were reported as directly related to an employee being asleep, even when an employee is apparently awake and alert at the time of an accident/incident (and excess service is not an issue), cumulative fatigue is often a contributing cause to an employee's poor judgment. Since an accident/incident investigation cannot always determine why a fully trained employee made a fatal mistake, the accident/incident data probably understates the magnitude of the fatigue problem.

The National Transportation Safety Board recognizes that the fatigue problem in the railroad industry is quite significant. According to NTSB Vice Chairman Robert Francis, in his February 25 testimony before your Subcommittee,

> [f]atigue . . . has been of great concern to the Safety Board for many years. [I]t remains one of the more perplexing problems to substantiate in accident investigations . . . . [The Safety Board believes] it is time that the FRA and the industry reassess the appropriateness of the Hours of Service Act . . . . The Act does not accommodate increased commuting distances crews encounter, or the need to properly eat, rest, or attend to personal matters, or address the advances in our scientific understanding of human work/rest scheduling requirements following these many decades of human factors research.

To illustrate the seriousness of the fatigue problem in the railroad industry, consider this transcript of a recorded telephone conversation between a locomotive engineer and a crew caller, both employees of a Class I railroad. The call for the engineer to report to duty came in the early morning hours, about one o'clock, last summer.

Engineer: "I haven't had any sleep. I'm just going to have to lay off. I haven't had a

chance to get any sleep."

Crew caller: "So you're telling me that you would probably work unsafe."

Engineer: "You can lay me off 'personal.' I am tired and 'account fatigue.' However you want to call that."

The crew caller said he could not allow the engineer to lay off on that basis.

Engineer: "We are not robots, though . . . ."

Crew caller: "I totally agree with you. They are working us 16 hours down here. We're getting . . . we're getting six hours of sleep and coming right back and working 16 more because we're short-handed, too, and I . . . I agree with you . . . ."

Although the crew caller expressed some sympathy for the engineer's situation, he warned that refusing the call would subject the engineer to discipline. In the end, the engineer accepted the call and went on duty, even though exhausted. The engineer told the crew caller, "Okay. If the railroad is willing to take the risk of employees that are fatigued, then that's just the way it's going to have to be."

This same incident could have happened on any number of railroads in this country. The solution is not easy. Allowing that engineer not to report would have probably meant that another engineer who had even less expectation of being called would be called to report in her place. The point is, however, that this is the kind of safety risk that railroads take, and that the country takes, by not taking stronger action to abate fatigue in the railroad industry.

Research on Fatigue and Alertness

FRA and NTSB accident/incident investigations, FRA SACP efforts, and research studies by Department of Transportation agencies, including FRA, working together as One DOT, and by other institutions have suggested the need to address irregular, unpredictable work cycles, with particular attention to promoting the alertness of crew members assigned to rapidly advancing shifts. Such work cycles typify the on-call system applicable to many operating employees, especially those involved in freight road service. Train and engine crews in road service are sometimes required to report for successive duty periods with as little as two hours' notice and only eight hours off between shifts, setting up a work/rest cycle of less than 24 hours. Research by FRA and others has determined that work/rest cycles shorter than 24 hours may lead to increased risk of incidents and injury. Moreover, because information regarding scheduling of trains is not readily available or is unreliable, or because employees in line to take earlier assignments report sick or are otherwise unavailable, an employee can be called to work suddenly without having had adequate sleep.

Cumulative fatigue, or sleep deficit, may also be a problem, particularly where assignments are scheduled to maximize crew availability within the laws (which permit returning to work with eight hours rest after a duty tour of eleven hours and fifty-nine minutes). FRA has also noted work patterns on some railroads that may require or permit employees to work long hours on many days successively without a day off, often leading to cumulative fatigue regardless of the work/rest cycle.

In addition, FRA researchers point out that age affects one's ability to adjust to an unpredictable work schedule. It is well known that, compared to younger employees, people over 40 years of age have greater difficulty adjusting to irregular work hours. A large percentage of locomotive engineers, 77 percent, are more than 40 years old and therefore having a harder time coping with the erratic hours often associated with being on call.

Study Using Locomotive Simulator

I would like to summarize the results of two related examples of FRA's studies to help determine the nature of performance decreases that operating employees may experience. In the first study,[1] FRA observed the performance of locomotive engineers on the Research and Locomotive Evaluator Simulator (RALES) facility at the Illinois Institute of Technology Research Institute. The RALES simulator was developed through FRA research and has served as the model for simulators used in the railroad industry worldwide to train locomotive engineers and assist in qualifying them. This study investigated how work schedules affect engineers' train handling performance and vigilance. Certified locomotive engineers performed normal job duties while operating a highly realistic locomotive simulator on two different work schedules. The work schedules were designed to conform with the Federal hours of service laws, to cause shifts to begin earlier each day at different rates, and to produce different levels of sleep deprivation. In

[1]The final report (DOT/FRA/ORD-97-09) is entitled "The Effects of Work Schedule on Train Handling Performance and Sleep of Locomotive Engineers: A Simulator Study," and was authored by Garold R. Thomas and Thomas G. Raslear of FRA and George I. Kuehn of the Illinois Institute of Technology Research Institute.

the group whose shifts started four hours earlier each day, engineers got an average of 4.6 hours of sleep. In the group whose shifts began only two hours earlier each day, engineers got an average of 6.1 hours of sleep. In both groups, as time went on across successive work periods, there were increased failures to sound the train horn at grade crossings, increased response times to the audible warning on the alerter, and increased use of fuel to operate the train.

The next phase of this work will include evaluation of on-duty napping strategies (similar to those being tested in international aviation and on railroads, e.g., The Burlington Northern and Santa Fe Railway Company's (BNSF) voluntary fatigue countermeasures program) and research into automated vigilance monitoring. In addition, other mitigation strategies designed to help engineers deal with shift work problems will be studied.

Study Using Diaries

Second, FRA, with the participation of the Brotherhood of Locomotive Engineers and major railroads, conducted a limited study of actual work patterns among engineers. We gathered "activity diaries" from 200 locomotive engineers employed by six railroads. The diaries consisted of self-reporting about quantity and quality of sleep, estimates of alertness at various times while on duty, time on duty, commuting time, and the accuracy of information provided to crews about job-start times. Here are some of the conclusions of this study:

* On average, participating engineers received almost the same amount of sleep as the general population, which was seven and one-half hours. However, for engineers with jobs starting between 10:00 p.m. and 4:00 a.m., sleep averaged less than six hours. This

means that the engineers who had had less rest than normal began their shifts during the late night and early morning hours, when lack of alertness would be expected.

* Engineers felt they were less alert during the early morning hours, and these periods of less alertness extended longer than would be expected for scheduled shift work.

* Engineers reported that the most important change that could improve their alertness was more accurate information about the time of the next job start (permitting better planning of rest).

FRA continues to analyze diaries gathered from a separate sample of engineers--those participating in the study of work, stress, and fatigue using the RALES simulator–to determine whether actual measures of performance on the simulator can be predicted using software designed to evaluate alertness based on work and rest cycles and biological rhythms.

Study on Railroad Dispatcher Training

In addition to these studies on locomotive engineers, FRA recently completed research to assist the railroad industry to improve the uniformity, quality, and efficiency of training for dispatchers, including training on fatigue issues. The research project had three goals: (1) to develop recommended training objectives; (2) to develop performance measures for candidates completing training; and (3) to develop model syllabi. In addition to many other specific recommendations, the research recommends that all training programs for dispatchers include a training objective which requires that trainees demonstrate the ability to apply lifestyle training, including information about shiftwork, to prepare for, and maintain, a career as a train dispatcher.

This training objective requires that trainees know the basic information concerning the relationship between shiftwork and fatigue, know the countermeasures that can be used to combat fatigue during a shift, and know the potential work-related problems of continually working third shift or being on-call with no regular schedule and no regular days off. Since it is common practice to also provide periodic refresher training to dispatchers, railroads that incorporate this training objective in their training will provide their dispatchers with the educational elements of a basic fatigue management plan. A brief summary of FRA's fatigue-related research and development and a bibliography of journal articles on fatigue and human factors issues specific to the railroad environment are appended to my testimony. See Appendix D and Appendix E, respectively.

Notwithstanding FRA's research effort on fatigue and unscheduled shift work, FRA lacks the regulatory authority provided to the Federal Aviation Administration and Federal Highway Administration to address hours of duty of safety-sensitive employees. As I have noted, Congress last enacted major amendments to the Federal hours of service laws in 1969; in the 29 years since then, railroad operations have changed materially. Human factors research into shift work, fatigue, and the body clock has produced a significant body of information that can help guide development of improved crew management practices.

Fatigue Initiatives under the Safety Assurance and Compliance Program

Anticipating the need to address identified issues of fatigue and lack of alertness by employees working long or irregular hours, in 1991 we requested complete regulatory authority over the area of hours of service, and in 1994 we requested a more limited authority to approve pilot projects, including waivers of the statute, proposed jointly by rail labor and management. Neither approach was productive.

Fortunately, however, during the past few years, railroads have launched a number of fatigue initiatives not requiring waiver of the hours of service laws. Under the Safety Assurance and Compliance Program (SACP), FRA has actively enlisted the cooperation of rail labor and management to identify and correct the root causes of systemic railroad safety problems, including fatigue. SACP responds to the President's directive to Federal regulatory agencies that their inspection and enforcement programs be designed to yield safety results, not simply to collect penalties. SACP also fulfills our duty under the Government Performance and Results Act to identify specific indicators that measure the overall success of the program. Under SACP, certain major railroads have developed innovative programs to address some of these issues.

Union Pacific and Southern Pacific: Train Crew Shortages and Other Problems; Guaranteed Days Off and Other Solutions

For example, on the Union Pacific Railroad Company and the Southern Pacific Transportation Company (collectively, UPSP), a SACP effort found that a root cause of the fatigue problem on the UPSP was inadequate staffing levels for train and engine service crews and poor crew utilization. FRA found that additional crews were needed to fill vacancies caused by attrition and to meet the demands for increased service. One factor contributing to the crew

shortage stemmed from the difficulty in anticipating when vacancies would occur. During the first half of 1997, UPSP experienced extremely low rates of retirement and attrition among train and engine service personnel, but the second half of the year saw a sharp increase in retirements. Another factor contributing to UPSP's crew shortage was an increase in train traffic brought about by an increase in business.

The unpredictability of job vacancies was compounded by the long development time that was necessary to properly train and qualify train and engine service personnel. UPSP provides a minimum of six months training to qualify a locomotive engineer, and additional time is required for engineers to become qualified on the territories in which they operate. Longer training and qualification periods were often necessary to operate freight trains in highly demanding service over mountain grade territory.

UPSP's crew shortage problem has been exacerbated by the fact that the railroad industry is currently experiencing a growth in employment for the first time since deregulation of the industry in 1980. For much of the past 15 years, as railroads have downsized, a pool of qualified employees was often readily available to fill vacancies on short notice; however, this situation no longer exists. Recently, railroads nationwide have been expanding the ranks of train and engine service personnel; consequently, an available reserve pool of qualified trainmen no longer exists.

UPSP is engaged in a hiring effort to augment staffing in key crafts. UPSP began an aggressive hiring program among train and engine service personnel, transportation and crew managers, and train dispatchers to address critical shortages of safety-sensitive personnel in the

operating and transportation departments. Since September 1, 1997, UPSP has hired 2,177 train and engine service personnel and 65 dispatchers. (These figures reflect overall hiring and do not represent net gains.) Furthermore, UPSP has projected attrition levels among train crews through the year 2015 in order to anticipate future hiring and training needs.

The SACP Working Group is also studying other causes of fatigue-related problems and recommending solutions involving napping, lodging, uninterrupted rest periods, education, improved crew utilization, and scheduling. Employee education and awareness efforts are beginning. In the fall of last year, UPSP sought direction and guidance from preeminent fatigue countermeasures specialists on how to resolve fatigue-related concerns. These specialists have developed two plans: a strategic plan describing the overall goal and approach for planning, implementing, and evaluating fatigue-related activities, and an operational plan stating specific objectives, strategies, and approaches for various projects or tasks, including major milestones and deadlines. Also last autumn, UPSP agreed to provide its train crews the right to guaranteed time off after working a predetermined number of days (one day off duty after seven days on duty); UPSP is the first major carrier to make such a system-wide commitment to address crew fatigue.

Burlington Northern Santa Fe: Fatigue Countermeasures Program

Meanwhile, The Burlington Northern and Santa Fe Railway Company (BNSF), working with the SACP Task Force, has developed one of the most advanced fatigue countermeasures program in the railroad industry. For example, to deal with acute fatigue during the workday, the

carrier has instituted a policy on napping that permits train crewmembers to take naps while on the job if certain rules are met. Only one train crewmember at a time is allowed to take a nap; there must be negotiation between the employees in the locomotive cab on who will take the nap; and the employee in charge of the locomotive controls is prohibited from taking a nap unless the train is stopped to meet or pass a train, waiting for track work, or is in other similar situations. (In addition to applying the napping policy to train crews, just this month BNSF started two pilot napping projects for maintenance-of-way workers.) BNSF has also provided ten hours of rest in situations when the statute calls for only eight hours. BNSF has established pilot programs where employees' off-duty time is not constantly subject to interruption by a duty call, where the employee has certain assigned days off, and where duty calls may occur only during certain time periods ("calling windows").

Finally, BNSF is exploring technological solutions to train crew fatigue. The railroad is currently establishing a pilot program of the Quantum Signal Comparitor System, which requires the engineer and conductor to enter signal aspects, slow orders, and operating authorities into a computer. The inputs must agree, or else a warning is sounded. If the crew fails to take prompt corrective action, the system stops the train. The activity required to accomplish these tasks will improve alertness, and if alertness drops below the required response time of the system, the system will stop the train.

North American Rail Alertness Partnership

As these approaches succeed, employees will be empowered to take responsibility for their own fitness for duty and have better tools to meet their safety responsibilities. FRA's work on fatigue through SACP efforts, and our continued research into fatigue and fatigue countermeasures, have stimulated a broad assault on fatigue and its effects, especially by evaluating the effectiveness of various scheduling and "strategic napping policy" changes. As a result, in 1997 we precipitated a joint partnership with passenger and freight railroads and major rail unions, the North American Rail Alertness Partnership (NARAP), to serve as a clearinghouse and discussion forum for ideas in this area. This was the first time ever that the industry had begun working together on fatigue and fatigue countermeasures on an industry-wide basis in an all-inclusive partnership in both the U.S. and Canada. Over the past ten months, all of the Class I railroad have come to the table and agreed to develop some sort of fatigue management program that will eventually become a part of their respective safety programs. Class II and regional railroads have also begun to enter the progress. FRA has also made contacts with light rail and commuter operations through the American Public Transit Association. The membership of NARAP also includes representatives from Transport Canada, Canadian Pacific Railway, and the National Transportation Safety Board. The scope of the membership reflects the objective of NARAP to identify and review fatigue-related projects underway or planned, regardless of the specific mode of transportation. A charter and a strategic plan have been developed for NARAP; consensus has been reached by the membership on both of these documents.

Through NARAP, FRA is disseminating information and promoting innovative approaches

that permit employees to schedule their rest, take time off when they need it to deal with cumulative fatigue, deal with acute fatigue, and prepare themselves to address the requirement for alertness when the body clock is in conflict with the railroad's need to move freight. NARAP also serves as a mechanism for FRA to obtain valuable insight on specific fatigue-related problems in the variety of operational settings and work groups. While no single approach may work everywhere, neither should we miss the opportunity to transplant approaches that will work elsewhere on the National rail system.

NARAP has documented 23 specific projects that are now underway on railroads, including on-duty napping strategies, mandatory days off, and designated calling windows. We are encouraged by the innovative pilot projects that some railroads have underway, and appreciate the efforts of NARAP to implement these projects and share information on them. Other strategies are continuing to be evaluated, and the willingness of employees and railroads to try new approaches has never been higher. Throughout the rest of 1998, FRA will place a major emphasis on the success of NARAP and of SACP action-plan items concerning employee fatigue.

Proposed Legislation to Combat Fatigue: the Federal Railroad Safety Authorization Act of 1998

Provision on Fatigue Management Plans

While FRA will continue to promote the joint fatigue initiatives of SACP and NARAP and the independent efforts of the leading carriers, we believe that legislative action is necessary to assure comprehensive, system-wide action. We believe our bill provides a realistic guide path to assure comprehensive, system-wide fatigue management planning on Class I and II freight

railroads and carriers providing commuter or intercity passenger service by the year 2000. Our bill will solidify and broaden the foundation built by NARAP and in certain SACP projects. Although some of these railroads are working actively on fatigue countermeasures, our bill will ensure that all of them address the fatigue issue in their operations in a comprehensive way.

We believe the fatigue countermeasures initiative in our bill is fully in line with current partnership efforts. The bill would require that a fatigue management plan be jointly developed by a railroad and its affected employees, where possible, and that employees would have the opportunity to comment to FRA on a railroad's proposed plan when such consensus is not possible. Moreover, the plans would be tailored to the root causes of fatigue on each railroad, rather than a one-size-fits-all approach. In developing their plans, railroads would be free to draw on what has been learned from the pilot projects that NARAP members have fostered. In fact, it is possible that NARAP could help develop model provisions of plans to cover subjects that are common on many railroads. Even after plans are in place, we believe that NARAP will continue to be an important forum for discussion of the evolving issues.

The plan would be due within one year of enactment. During the first two years after enactment, compliance with a plan not involving a statutory waiver would be voluntary. Those portions of plans involving a waiver would be mandatory immediately. After two years, compliance with the plans would become mandatory, and FRA would be authorized to issue regulations requiring additional railroads to submit plans.

The bill's provision is flexible and results-oriented, both in specifying the general subjects to be addressed but not demanding that they be addressed in only one way, and in giving railroads two years to fine-tune their programs before they become mandatory. The provision uses a systems safety approach, requiring that the problem of fatigue be addressed as a whole and in the context of the railroad's general operations rather than piecemeal. Transportation safety experts uniformly acknowledge the desirability of taking a systems approach to safety. Finally, the provision also gives railroad management and labor incentives to take action against fatigue: first, an incentive to come to agreement on ways to reduce fatigue on the job and fatigue-caused accidents/incidents by authorizing waiver of the statutory provisions upon joint petition by labor and management; and, second, an incentive to move employees from an irregular, on-call system to a scheduled system by requiring fewer subjects to be addressed in the plan for scheduled employees than for on-call employees.

Each fatigue management plan would have to address specific, enumerated issues. These include such important matters as:

* basic education and training on physiological and psychological factors that affect fatigue, to give employees the scientific tools to manage their fatigue knowledgeably;
* identification and treatment of sleep disorders, which are very common;
* scheduling practices regarding train lineups and calling times, including work/rest cycles;
* an analysis showing that staffing levels and workloads were considered when the plan was developed, to prevent work overloads;
* alertness strategies to deal with acute fatigue on duty, such as policies on napping; and
* opportunities for undisturbed sleep at lodging facilities.

If all of the railroad's covered service employees are on a regular schedule, no more specific topics need to be addressed. However, if some of the railroad's covered service

employees are in unscheduled service, additional issues would have to be addressed, such as increasing the number of hours of undisturbed rest and enhancing the predictability of work schedules by lengthening the notice provided for reporting to duty. FRA's fatigue research has stressed the overriding importance of notice of start time.

Highlights on Necessary Hours-of-Service Safety Amendments

The bill would also make some specific substantive changes in the hours of service statute to take effect immediately. For example, one set of these technical amendments would ensure that the current statutory restrictions cover all persons, not simply railroad employees, who maintain railroad signal systems for a railroad. This group of provisions would eliminate the unsafe and unfair current situation of having people working side by side doing the same work, some of whom are covered by the hours of service laws and some of whom are not. In some instances, railroad signals are installed, repaired, and maintained not by railroad employees but by contractors and subcontractors to railroads. We must remember that an exhausted contractor employee doing railroad signal work could cause a major accident/incident by something as simple as installing a relay backwards. This set of amendments would also clarify the existing coverage of persons who engage in dispatching or train service as contractors.

Other proposed amendments to the hours of service laws would regulate the hours of employees who work for more than one railroad or contractor to a railroad. This assures that employees with multiple railroad jobs are treated the same as employees who work for only one

railroad. FRA is aware of a number of employees who perform signal work for more than one railroad. Often they work on critical grade crossing signals. Almost every year, fatalities caused by grade crossing accidents/incidents make up about half of all railroad-related fatalities. A serious safety hazard could result if a dually employed person performing the signal maintenance is not given the same minimal protections of the hours of service laws as an employee who works for only one railroad.

Finally, the bill would make a signal employee's last hour returning from a trouble call not off-duty time but "limbo time." (Limbo time is not counted as either time on duty or time off duty.) There is no safety rationale for giving a signal maintainer less time available for rest than other covered employees receive.

In summary, the fatigue management plans provision and the hours of service technical amendments together offer a comprehensive approach to the problem of fatigue in the railroad industry. The NTSB has long recognized this problem. We believe that this approach will build on industry initiatives against fatigue that reach a limited number of railroad employees in covered service. The bill would assure similar protections against fatigue for all railroad employees in covered service nationwide.

Conclusion

In closing, advancing safety initiatives against fatigue and other hazards throughout an industry of 265,000 employees and 220,000 miles of track, 280,000 highway-rail crossings,

20,000 locomotives and more than a million cars, and thousands of facilities is a daunting but absolutely essential task. The safety of every employee demands it. The economy demands it. The country's 21st century transportation future demands it.

As I have pointed out, several elements of the Administration's rail safety reauthorization bill are based on the many lessons of the past few years that I have reviewed today. We believe that enactment of the Federal Railroad Safety Authorization Act of 1998 is critical to maintaining the continuous safety improvement that we have achieved to date. The legislation will allow FRA to fulfill its safety mission by focusing its limited resources in large part on the fatigue issues we have discussed today as well as on critical issues of safety culture and our existing regulatory mandates. Madam Chairman, I appreciate this opportunity to testify, I look forward to your help and support as we move forward with our rail safety agenda, and I again offer our assistance as the Subcommittee considers important rail safety legislation.

Appendix A

FRA's Regulatory Agenda

Recent Regulatory Achievements

Since February 1998, FRA has issued a number of statutorily mandated and other proposed or final rules, through either traditional notice-and-comment rulemaking or through collaborative processes, including the Railroad Safety Advisory Committee (RSAC). The following list summarizes the key areas covered by major proposed or final rules that FRA has promulgated in the past seven months.

Statutorily Mandated Rules

* **Revisions to power brake rules for freight service.** This proposed rule would revise and clarify existing standards and establish new standards for dynamic brakes. (Published September 9, 1998.)

* **Revision of Track Safety Standards.** This final rule amends existing standards to reflect developments in technology and changes in operations, and covers subjects such as continuous welded rail and excepted track. For the first time, the rules address train operations at speeds more than 110 mph. (Published June 22, 1998.)

* **Passenger train emergency preparedness.** This final rule requires that each commuter and intercity passenger railroads submit and comply with an emergency preparedness plan that addresses issues such as (i) communication of the initial emergency notification, (ii) employee training for emergencies, (iii) liaison with emergency responders, (iv) on-board emergency equipment, and (v) passenger safety information. It also requires that emergency windows be clearly marked on the inside and outside of the car and be inspected periodically. (Published May 4, 1998.)

Other Rules

* **Railroad communications.** This final rule revises and augments the existing rules on Radio Standards and Procedures based on the notice of proposed rulemaking (NPRM) recommended by the Railroad Safety Advisory Committee (RSAC) working group. This regulation ensures that trains and roadway workers have the communications capabilities that they need to perform their duties, including prompt emergency response in the event of a personal injury or threat to the environment from a damaged hazardous materials car. (Published September 4, 1998.)

* **Revisions to steam locomotive standards.** This proposed rule would incorporate recent National Transportation Safety Board (NTSB) recommendations for steam boiler safety and reduce regulatory burdens on small railroads that use these historic locomotives in

infrequent excursion service. (Issued August 28, 1998.)

* **Revisions to locomotive engineer certification rule.** This proposed rule would revise and enhance existing safety standards in accordance with recommendations of the RSAC. Among the safety issues addressed is the NTSB's recommendation regarding improved tests for color blindness. (Issued September 8, 1998.)

* **Advanced Civil Speed Enforcement System Order.** This final order requires all trains operating between New Haven and Boston on the Northeast Corridor to be equipped with a transponder-based system called ACSES, which, when paired with the existing automatic cab signal or automatic train control system, will deliver all the core functions of positive train control, including positive stop enforcement at home signals and enforcement of temporary and permanent speed restrictions. The order supports increased densities and speeds up to 150 miles per hour by late 1999. (Published July 22, 1998.)

* **End-of-train braking devices for passenger trains.** This final rule establishes standards for the use of two-way end-of-train devices on passenger trains that contain freight cars, in order to address the unique characteristics of such mixed trains. (Published May 1, 1998)

Pending Congressional Mandates

Congress has defined much of FRA's regulatory agenda over the past decade, and FRA completed many recent rulemakings pursuant to statutory mandate. Since 1988, FRA has completed 21 of the 24 rulemakings required by Congress. Remaining critical rulemakings not yet completed include freight power brake, passenger equipment, and whistle bans.

Revision of the Freight Power Brake Rules

In the 1992 safety reauthorization, Congress required FRA to review its power brake rules and "revise [them] based on such safety data as may be presented" and further mandated standards on dynamic braking and rules requiring two-way end-of-train devices by December 31, 1997, except on certain types of trains. In response, FRA in 1994 published an NPRM to revise the power brake rules generally.

Although FRA proposed an innovative, performance-based regulatory approach to power brake safety issues, railroad labor, freight, and commuter representatives raised significant questions about requisite cost-benefit data and other issues. FRA accordingly reconsidered its overall regulatory initiative with respect to Congress' broad power brake mandate.

In order to ensure swift regulatory action on two-way end-of-train safety devices, FRA separated this subject from the larger freight power brake rulemaking. FRA published a final rule in January 1997, railroads agreed to an expedited implementation schedule, and trains nationwide were equipped with necessary two-way end-of-train devices ahead of the Congressionally mandated deadline of December 31, 1997.

FRA similarly separated passenger equipment power brake provisions and included this subject in the passenger equipment NPRM published in September 1997. FRA is in the final stages of preparing that rule for clearance within the executive branch.

Finally, because FRA believed that a collaborative approach could facilitate resolution of the remaining freight power brake issues, FRA elected to refer this issue to the newly-formed RSAC in April 1996. Unfortunately, despite the best efforts of the parties, RSAC was unable to reach consensus on this subject, and FRA formally withdrew the task in June 1997. On September 9, 1998, FRA published a second NPRM reflecting the knowledge gained through the collaborative RSAC process.

Passenger Equipment Safety

In September 1994, the Secretary of Transportation announced that the Department would develop comprehensive Federal safety standards for rail passenger equipment over a five-year period. Soon after, in November 1994, Congress adopted the Secretary's schedule for implementing these safety standards, making it part of the Federal Railroad Safety Authorization Act of 1994. The Act provided that "initial" final regulations dealing with at least certain subjects be established by November 2, 1997, and final regulations by November 2, 1999.

Consistent with the intent of Congress that FRA consult with the railroad industry in prescribing safety standards for rail passenger equipment, FRA formed a working group comprising representatives from rail labor organizations, commuter railroads, Amtrak, States, and other entities to focus on and effectively address the safety of such equipment. This consultative effort started in June 1995 and greatly contributed to the development of an Advance Notice of Proposed Rulemaking (ANPRM), issued in June 1996, and an NPRM, issued in September 1997. FRA has twice convened the working group to discuss the comments received in response to the proposed rule, and is nearing completion of the final rule.

With issuance of an initial final rule for Passenger Equipment Safety Standards a few months from now, FRA will have established the first comprehensive Federal rules for this class of service. These include requirements for: *system safety planning,* focusing on aspects of the railroad system integral to equipment safety; *equipment structure and design,* such as end, corner, and side structures in passenger cars (to protect occupants from crushing), fuel tanks, and interior-fitting strength (to prevent detachment of seats); *passenger car escape and rescue access,* requiring such features as emergency door-release mechanisms and emergency lighting; *fire safety*; and *equipment inspection, testing, and maintenance,* revising the power brake standards for passenger equipment and developing new standards for (non-brake) mechanical components.

Much more work, however, is required in the second phase of the passenger proceeding, including—

* A review of operating practices pertinent to passenger safety, including arrangements and procedures at stations; and

* Improvements to the initial standard in key areas such as emergency lighting, corner post strength, and fire safety.

Ongoing research and the American Public Transit Association's Passenger Rail Equipment Safety Standards Task Force will provide important contributions to this work, which will continue at least through 1999.

Whistle Bans

FRA has determined that a detailed environmental assessment (EA) and an environmental impact statement (EIS), will be required for the train horn rulemaking. FRA's internal schedule calls for preparation of the draft EA before the end of the year. FRA will issue the EIS along with the NPRM, which is already in review and clearance within the executive branch. The public will then have an opportunity to comment on both documents at the same time.

FRA continues to lay the groundwork for accomplishing the challenges presented by this Congressional mandate, which was enacted in 1994 and amended in October of 1996. In addition to conducting a national study of train whistle bans, FRA has reached out to more than 200 communities that have whistle bans or wish to enact them. FRA also has gathered data on additional crossings in the Chicago region that the outreach identified as impacted by whistle bans, and has refined the collision-exposure analysis using that data.

In order to advance development of supplementary safety measures that can take the place of the train horn, FRA has worked with several communities to develop proposals for "quiet zones." Some of those projects are already moving out of the planning phase into the implementation phase. Currently, FRA is working with Spokane County, Washington, to demonstrate and evaluate a new median-barrier installation at a crossing where trains are now running silent. FRA monitors a four-quadrant gate installation in Broward County, Florida, where train horns on the Tri-Rail commuter line will be silenced in the next phase of testing. In addition, FRA utilizes data from projects initiated under section 1010 of the Intermodal Surface Transportation Efficiency Act of 1991 (designated high-speed rail lines) and other sources to refine FRA estimates of effectiveness for the various alternatives to train horns.

The Regulatory Challenge Ahead

FRA is moving aggressively to complete these three pending rules based on statutory mandates. In addition, FRA is moving ahead on its broader regulatory agenda, incorporating the RSAC process or other collaborative mechanisms where possible. Key initiatives include rules on positive train control, locomotive cab working conditions, and safety integration plans.

Rail Equipment Accidents/Incidents
Reported to FRA

Year	Number Caused by Human Factor(s)	Total Number*	Percent Caused by Human Factor(s)
1991	887	2814	31.5
1992	864	2531	34.1
1993	865	2785	31.1
1994	911	2669	34.1
1995	944	2619	36.0
1996	783	2584	30.3
1997	855	2560	33.4

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* Figures reflect all rail equipment accidents/incidents, including highway-rail crossing collisions that caused railroad property damage above the dollar reporting threshold.

Appendix C

The Railroad Industry's Safety Record

In the 1993-1997 period, FRA's safety reinvention efforts have been very successful. Between 1993 and 1997, the major safety indicators significantly improved. Preliminary data for the first five months of 1998 suggest further improvements. For example:

* Between 1993 and 1997, *rail equipment accidents/incidents** fell 8.2 percent. In 1997 alone, rail equipment accidents/incidents fell about 2 percent from 1996 levels (from 2,443 to 2,397), and there was a reduction in the rate per million train miles from 3.64 to 3.54. Between January and May 1998, the rail equipment accident/incident rate fell to 3.45, the lowest rate for the same period of all the years between 1993 and 1998. (See Attachments 1-2.)

* From 1993 through 1997, *employee on-duty cases, which include reportable injuries, illnesses, and fatalities,* fell 46 percent, and the frequency of cases per 200,000 hours worked fell 44 percent. For 1997, there was a reduction from the 1996 level of 10 percent (from 9,232 to 8,302), and there was an almost 10 percent reduction in the frequency that employees are hurt (from 3.66 to approximately 3.31). In the first five months of 1998, the downward trend continued; there were 2,948 cases, compared to 3,382 in the same period of 1997, and a rate of 2.77 compared to 3.25, an almost 15 percent reduction in the rate. (See Attachments 3-4.)

* From 1993 through 1997, *crossing collisions* fell 21 percent. For 1997, there was a 9.2 percent drop from the prior year level, from 4,257 to 3,865. (See Attachment 5.) From 1993 through 1997, *crossing injuries* fell 16 percent. For 1997, there was a 4.3 percent reduction from 1996 levels, from 1,610 to 1,540. From 1993 through 1997, *crossing fatalities* fell 26 percent. For 1997, there was a 5.5 percent reduction from 1996 levels, from 488 to about 461. In the first five months of 1998, there were 175 crossing fatalities compared to 188 in the same time in 1997.

* After nine fatalities to passengers in rail equipment accidents/incidents in 1996 (one at Secaucus and eight at Silver Spring), we experienced one passenger fatality in collisions, derailments, or other property-damage accidents/incidents in 1997. (Amtrak reported to FRA that the death occurred as a result of the August 9, 1997, derailment at Kingman,

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*These numbers exclude highway-rail crossing collisions that caused sufficient railroad property damage to qualify as a rail equipment accident/incident. There were 2,611 rail equipment accidents/incidents in 1993.

Arizona, about six weeks after the event.) The 1997 figure represents an important safety achievement, in view of the 300 million passenger trips provided by Amtrak and the commuter railroads each year. Five passengers did lose their lives in train incidents (in events such as jumping from a moving train) in 1997.

Yet, as we told this Subcommittee on February 25, <u>*not all*</u> of the news is good. We felt that 1996 was a very unfortunate year for *employee fatalities* with 33, yet in 1997, we investigated 37 railroad employee fatalities that resulted from other than natural causes (two of which were homicides). Some of these deaths resulted from general hazards, such as the seven fatalities to on-duty employees in motor vehicle incidents, most of which were off railroad property. As part of a One DOT effort, we emphasize seatbelt use and other strategies to prevent motor vehicle accidents and to mitigate their consequences. The twelve employees killed in switching-related incidents and seven killed in train collisions also powerfully motivate us to find a prevention program that will eliminate these chronic rail safety results. Other fatalities involving industrial hazards in working conditions that are unique to the railroad industry are also high on our priority list. Our Acting Associate Administrator for Safety, George Gavalla, has formed a working group to explore the causes of fatalities to train and engine crews during switching operations. The group will seek to find remedies to the conditions and behaviors that have made this a problem that has not been addressed with complete success since the inception of the industry.

From 1993 to 1997, *total fatalities* associated with railroad operations (including grade crossing and trespasser fatalities) fell 16.9 percent. In 1997 alone, however, we experienced a 2.3 percent increase. This increase was generated by a significant rise in *trespasser fatalities* (which exclude fatalities at grade crossings). In 1997, trespasser fatalities--for the first time--clearly eclipsed highway-rail crossing fatalities as the largest single component of fatalities in railroad operations. Trespasser fatalities rose 13 percent from 471 reported in 1996 to 533 in 1997. In 1998, FRA is putting renewed emphasis on finding solutions to trespassing that will fit the many forms in which it appears. Unlike many other railroad safety problems, trespassing is very much a local and regional issue that requires targeted solutions. Trespassing is a problem that in various parts of our Nation involves the homeless, immigrants, children, and other dimensions. It is also a problem sometimes made worse when the media make it appear that the tracks are a place for recreation. We are seeking to address each of these elements of the problem. For example, in April of 1997, we submitted to the Congress, pursuant to a 1994 Congressional mandate, model State legislation against railroad trespassing. We have distributed the model bill widely, and it has been enacted in at least one state (Iowa).

We can also expect new challenges in the area of grade crossing safety with the completion of new regulations regarding whistle bans. The growth in railroad traffic has coincided with an increase in the population. During the past several decades many towns and cities have sprung up along railroad rights-of-way. Rail lines that once traversed uninhabited rural areas are now adjacent to thriving communities. In order to accommodate the needs of railroad safety with the needs of communities for a livable environment, Congress has mandated that FRA develop safety standards to regulate the use of train horns and whistles at highway-rail grade crossings. FRA is confident that the whistle ban regulation that is currently being developed can

meet those needs; however, we anticipate that a heightened level of effort and cooperation will be required between FRA and thousands of local communities.

Safety is improving where we have well-honed tools to address safety needs. Clearly, however, we still have much work to do, and we need fresh approaches to address the old, continuing challenges, such as switchyard casualties and trespassing, that have defied resolution in the past and to meet the new challenges, such as implementing future whistle ban regulations, that now lie ahead for the agency.

Appendix D

APPENDIX ON HUMAN FACTORS RESEARCH

BACKGROUND

Approximately one-third of all rail equipment accidents/incidents are caused by human error. The Federal Railroad Human Factors Research Program has focused on identifying the root causes for human error affecting safety in the railroad industry. The goal of this research program is to reduce the frequency and severity of accidents/incidents attributable to human error. Technologies, practices, and procedures evolved from research and development (R&D) on the effects of stress and fatigue are expected to provide one of the means for reaching this goal while improving railroad operating efficiency and environmental quality. FRA is working in conjunction with the other modal administrations to address stress and fatigue issues.

Workload, Stress, and Fatigue

A primary purpose of this technical activity is to determine whether work schedules that are commonly encountered in railroad operations produce sufficient fatigue (lack of alertness) and stress in locomotive engineers, dispatchers, and other railroad personnel to compromise the safety and efficiency of their work performance. A related question concerns the amelioration of such fatigue and stress by adjustments in work schedules, crew calling procedures, hours of service requirements, work environment, etc. Currently, there are sub-activity areas addressing this topic in enginemen, high-speed operations, yard and terminal operations, and dispatchers.

Locomotive Engineer Stress and Fatigue

The **Enginemen Stress and Fatigue Phase II** project was initiated in April 1992. The central question in this study is whether the hours of service laws and work schedule produce sufficient fatigue and stress in locomotive engineers to compromise the safety of their work performance. Fifty-five experienced, certified locomotive engineers were used as test subjects. Each subject was observed during a one-week period on the Research and Locomotive Evaluator/Simulator (RALES) facility at the Illinois Institute of Technology Research Institute (IITRI). The current law governing hours of service for locomotive engineers allows work schedules that have backwards-rotating shift-start times. Locomotive engineers who work under such schedules can accumulate a progressive sleep debt over a period of days. The locomotive engineers in this study, while working on such schedules, reported progressive decrease in subjective alertness across the duration of the study. Several aspects of job performance, including safety-sensitive tasks, degraded during the same time period. The final report on this work has just been published.

Evaluation of **Mitigation Strategies** began in FY 1997. This activity consists of multiple projects designed to identify and test the intrusion of stress and fatigue on locomotive engineers' performance. The first two projects will be to look at (i) the use of planned, on-duty napping and (ii) vigilance monitoring. The use of napping to mitigate fatigue has become a focus of interest in the railroad industry and in other industries, notably aviation and trucking. The purpose of this project will be to examine and evaluate napping strategies that are compatible with railroad operations. The project will support decision-making in the Office of Safety regarding the necessity of changes in the hours of service laws, other rail safety laws, or FRA regulations. The project will be conducted at IITRI on the RALES. In the second project, existing vigilance-monitoring devices, and those known to be in advanced stages of development, will be evaluated to determine their usefulness in the railroad operating environment. This evaluation will be followed either by testing the most promising devices or attempting to develop a new device based on technology employed in various research activities for data acquisition. In addition to napping strategies and vigilance monitoring, changes in work environment, and scheduling and crew calling practices are other strategies that are likely to be evaluated.

Locomotive Engineer Work/Rest Cycles

This project began in 1998 to extend the analysis of locomotive engineer diary data that was previously collected by the Volpe National Transportation Systems Center in 1996 for FRA. On-call railroad employees are often forced into work/rest cycles either shorter than, or longer than, a typical 24-hour day. Numerous laboratory studies have shown that forced rest/activity cycles outside the body's normal range of entrainment can lead to circadian rhythm desynchronization, chronic fatigue, and impaired performance. A recent study by the FRA demonstrated that work/rest cycles shorter than 24 hours do indeed impair locomotive engineer performance in a locomotive simulator. No studies prior to the FRA simulator study have established the effects of work/rest cycles shorter than 24 hours in on-call railroad operations. Data from this study corroborate these findings and extend them to suggest how often, and under what circumstances, shorter-than-24-hour work/rest cycles occur in on-call railroad operations. Diary data from 198 locomotive engineers working on several railroads were analyzed. Across on-call assignments, locomotive engineers, on average, worked a shorter-than-24-hour work/rest cycle about one-third of the time (about 40 percent of the time for extraboard engineers). When engineers completed a shorter-than-24-hour work/rest cycle, they had significantly more sleep and subsequent alertness problems than when they completed a longer-than-24-hour work/rest cycle even though engineers were provided the statutorily required minimum of eight hours' rest (or more). Information suggests that shorter-than-24-hour work/rest cycles in on-call operations may put employees at greater risk for fatigue-related incidents, and that the federal requirement for a minimum eight hours of rest may not be enough.

High-Speed Train Operations

The **Information-Mediated Fatigue and Stress in Railroad Operations** Project began in 1996. It is intended to examine the workload, stress, and fatigue issue within the special context of high-speed operations to determine if there is a synergism of speed, sleep loss, and work/rest cycles in producing operator fatigue. High-speed operations increase the flow of information that is used by locomotive engineers to control the train. While train speeds increase, the ability of human beings to process information remains constant. As a result, human operators experience increased mental workload, and consequent stress and fatigue, in a high-speed operating environment. When the effects of speed, *per se*, on workload, stress, and fatigue have been determined, the project will examine speed effects in combination with circadian rhythms, sleep loss, and work/rest schedules.

Yard and Terminal Safety

As part of an effort to make a preliminary determination of the root causes of yard and terminal accidents/incidents, Phase I of the Yard and Terminal Safety Project examined the time of day at which accidents occurred. It was found that accidents/incidents peaked during the early morning (2:00 a.m. to 4:00 a.m.) and late afternoon (6:00 p.m.). This result is consistent with circadian patterns of fatigue observed in other industries and suggests that work/rest cycles and work schedules may be causal factors in many yard and terminal accidents/incidents. Phase II of this project began in March 1998 and will extend the observations of Phase I. Specifically, Phase II will further document the relationship of time of day to worker injuries and will compare key work/rest variables for injured and uninjured employees.

Dispatcher Workload, Stress, and Fatigue

There are three projects under this sub-activity which are intended to occur sequentially, dependent upon the success of the preceding phase. Phases I and II began in FY 1996.

The **Dispatcher Workload, Stress & Fatigue, Phases I, II & III** Projects will develop objective and reliable evaluations of train/railroad dispatcher's workloads, occupational stress, and fatigue. A 1987 survey of train dispatching offices and practices found that dispatchers were subjected to work overloads and heavy safety responsibilities. It was also found that there were some locations and instances where personnel were required or permitted to work on their assigned rest days. Together, these findings lead to concern about the effects of workload, stress, and fatigue on performance and safety. Phase I, completed in October 1997, identified candidate measures of workload, stress, and fatigue which are objective, well-defined, and suitable for use in the dispatcher's workplace (unthreatening, and as least intrusive or time-consuming as possible). Phase II evaluated the candidate measures to identify and document those most suited for FRA use. Phase III, currently underway, will use the chosen measures in a full study of dispatcher workload, stress, and fatigue. Phase III was initiated in late FY 1998.

Future Technology

While the initial High-Speed Human Factors program addressed human-factor issues relating mostly to high-speed trains, the current program has grown considerably in scope and purpose since its inception. As emerging technologies continue to increase the complexity of all aspects of the railroad industry, broader human-factor concerns that impact both high-speed and slower speed operations need to be addressed. Operators, for example, must be able to quickly understand and respond to complex information in a dynamic environment. How that critical safety-related information is displayed and communicated, then, becomes increasingly important in one's ability to respond safely and efficiently to that information. Therefore, methods of communication, the presentation of information, and the design of various technological devices, should be evaluated for their impact on performance and decision-making *before* they are implemented.

Under this focus area, future and current work will focus on issues such as digital communications, locomotive display guidelines, and the impact of crew teaming (i.e., engineer, conductor, dispatcher, maintenance personnel, etc.) on critical decision-making. Methods are currently being developed to better categorize and understand the communication processes and cognitive representations used by operations experts in their jobs. With this information, software engineers can then design improved displays and sensory feedback systems that increase the saliency of key information to be used by these individuals in their critical decision-making processes. As new technological devices, visual displays, and other cognitive feedback systems are developed, specific features and design components will be tested for their capabilities of minimizing operator error.

Appendix E

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